# Worksheet 3 Binary arithmetic Answers

**Task 1**

Carry out the following binary sums showing your working out:

1. 1012 + 1112

|  |  |  |  |
| --- | --- | --- | --- |
|  | 1 | 1 |  |
|  | 1 | 0 | 1 |
|  | 1 | 1 | 1 |
| **1** | **1** | **0** | **0** |

1. 101102 + 101112

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| 1 |  | 1 | 1 |  |  |
|  | 1 | 0 | 1 | 1 | 0 |
|  | 1 | 0 | 1 | 1 | 1 |
| **1** | **0** | **1** | **1** | **0** | **1** |

1. 112 + 1000012 +1012

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  |  | 1 | 1 | 1 |  |
|  |  |  |  | 1 | 1 |
| 1 | 0 | 0 | 0 | 0 | 1 |
|  |  |  | 1 | 0 | 1 |
| **1** | **0** | **1** | **0** | **0** | **1** |

1. 101012 + 1110112 + 10012

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| 1 | 1 | 1 | 1 | 1 | 1 |  |
|  |  | 1 | 0 | 1 | 0 | 1 |
|  | 1 | 1 | 1 | 0 | 1 | 1 |
|  |  |  | 1 | 0 | 0 | 1 |
| **1** | **0** | **1** | **1** | **0** | **0** | **1** |

Show how the following values can be stored as binary bytes within a computer system and determine the answer that would be calculated and stored:

1. 1210 + 1310

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **128** | **64** | **32** | **16** | **8** | **4** | **2** | **1** |
|  |  |  | 1 | 1 |  |  |  |
| 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 |
| 0 | 0 | 0 | 0 | 1 | 1 | 0 | 1 |
| **0** | **0** | **0** | **1** | **1** | **0** | **0** | **1** |

1. 17410 + 25510

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  |  | 1 | 1 | 1 | 1 | 1 | 1 | 1 |  |  |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 1 | 1 | 1 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| **0** | **0** | **0** | **0** | **0** | **0** | **0** | **1** | **1** | **0** | **1** | **0** | **1** | **1** | **0** | **1** |

1. 1910 + 6610 + 7410

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| 1 |  |  |  |  | 1 |  |  |
| 0 | 0 | 0 | 1 | 0 | 0 | 1 | 1 |
| 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 |
| 0 | 1 | 0 | 0 | 1 | 0 | 1 | 0 |
| **1** | **0** | **0** | **1** | **1** | **1** | **1** | **1** |

Answer the following question:

1. A computer has been designed to work only in single bytes of data. Describe the problem that will be encountered when carrying out the sum 011110012 + 111110012 if the answer is only allocated one byte of storage.

* The answer is 101110010 which is 9 bits
* A byte is 8 bits so answer is too long to store and byte would be 01110010
* Calculation results in an overflow error indicating the resulting 8 bits have an incorrect answer and should be discarded

# Task 2 Binary multiplication Answers

Carry out the following binary multiplications showing your working out:

1. 10112 x 102

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  |  | 1 | 0 | 1 | 1 |
|  |  |  |  | 1 | 0 |
|  |  | 0 | 0 | 0 | 0 |
|  | 1 | 0 | 1 | 1 | 0 |
|  | **1** | **0** | **1** | **1** | **0** |

1. 111002 x 1012

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| 1 | 1 | 1 |  |  |  |  |  |
|  |  |  | 1 | 1 | 1 | 0 | 0 |
|  |  |  |  |  | 1 | 0 | 1 |
|  |  |  | 1 | 1 | 1 | 0 | 0 |
|  |  | 0 | 0 | 0 | 0 | 0 | 0 |
|  | 1 | 1 | 1 | 0 | 0 | 0 | 0 |
| **1** | **0** | **0** | **0** | **1** | **1** | **0** | **0** |

1. 1100112 x 11102

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 1 | 1 | 1 | 1 | 1 | 1 | 1 |  |  |  |
|  |  |  |  | 1 | 1 | 0 | 0 | 1 | 1 |
|  |  |  |  |  |  | 1 | 1 | 1 | 0 |
|  |  |  |  | 0 | 0 | 0 | 0 | 0 | 0 |
|  |  |  | 1 | 1 | 0 | 0 | 1 | 1 | 0 |
|  |  | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 |
|  | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 0 |
| **1** | **0** | **1** | **1** | **0** | **0** | **1** | **0** | **1** | **0** |

1. 101012 x 1000112

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  | 1 |  |  |  |  |  |  |
|  |  |  |  |  | 1 | 0 | 1 | 0 | 1 |
|  |  |  |  | 1 | 0 | 0 | 0 | 1 | 1 |
|  |  |  |  |  | 1 | 0 | 1 | 0 | 1 |
|  |  |  |  | 1 | 0 | 1 | 0 | 1 | 0 |
|  |  |  | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
|  |  | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
|  | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| **1** | **0** | **1** | **1** | **0** | **1** | **1** | **1** | **1** | **1** |

1. 10101112 x 1011112

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | 1 | 1 | 10 | 10 | 10 | 10 | 10 | 10 | 1 |  |  |
|  |  |  |  |  | 1 | 0 | 1 | 0 | 1 | 1 | 1 |
|  |  |  |  |  |  | 1 | 0 | 1 | 1 | 1 | 1 |
|  |  |  |  |  | 1 | 0 | 1 | 0 | 1 | 1 | 1 |
|  |  |  |  | 1 | 0 | 1 | 0 | 1 | 1 | 1 | 0 |
|  |  |  | 1 | 0 | 1 | 0 | 1 | 1 | 1 | 0 | 0 |
|  |  | 1 | 0 | 1 | 0 | 1 | 1 | 1 | 0 | 0 | 0 |
|  | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1 | 0 | 1 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 |
| **1** | **1** | **1** | **1** | **1** | **1** | **1** | **1** | **1** | **0** | **0** | **1** |

1. 1110102 x 1010012

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 1 | 1 | 1 | 1 | 1 | 1 | 1 |  |  |  |  |  |
|  |  |  |  |  |  | 1 | 1 | 1 | 0 | 1 | 0 |
|  |  |  |  |  |  | 1 | 0 | 1 | 0 | 0 | 1 |
|  |  |  |  |  |  | 1 | 1 | 1 | 0 | 1 | 0 |
|  |  |  |  |  | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
|  |  |  |  | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
|  |  |  | 1 | 1 | 1 | 0 | 1 | 0 | 0 | 0 | 0 |
|  |  | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
|  | 1 | 1 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| **1** | **0** | **0** | **1** | **0** | **1** | **0** | **0** | **1** | **0** | **1** | **0** |

For each of the previous questions, convert the values into decimal and check they are correct.

1. 11 x 2 = 22
2. 28 x 5 = 140
3. 51 x 14 = 714
4. 21 x 35 = 735
5. 87 x 47 = 4089
6. 58 x 41 = 2378

# Task 3 Binary subtraction Answers

Convert these decimal values into two’s complement binary bytes:

1. -5010 = 11001110
2. -12010 = 10001000
3. 12710 = 01111111
4. -12810 = 10000000
5. Show that -5010 gives the same result as in (a) above using the following alternative method:

Assume the left-most bit represents -128. Start at -128 and then add the remaining values:

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| -128 | 64 | 32 | 16 | 8 | 4 | 2 | 1 |
| **1** | **1** | **0** | **0** | **1** | **1** | **1** | **0** |

Carry out the following calculations in two’s complement binary bytes:

1. -5010 -3010 *or* -5010 + -3010

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| 1 |  |  | 1 | 1 | 1 |  |  |
| 1 | 1 | 0 | 0 | 1 | 1 | 1 | 0 |
| 1 | 1 | 1 | 0 | 0 | 0 | 1 | 0 |
| **1** | **0** | **1** | **1** | **0** | **0** | **0** | **0** |

1. -6610  + 3410

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | 1 | 1 | 1 | 1 | 1 |  |  |
| 1 | 0 | 1 | 1 | 1 | 1 | 1 | 0 |
| 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 |
| **1** | **1** | **1** | **0** | **0** | **0** | **0** | **0** |

1. -8810 - 1210

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| 1 | 1 |  |  |  |  |  |  |
| 1 | 0 | 1 | 0 | 1 | 0 | 0 | 0 |
| 1 | 1 | 1 | 1 | 0 | 1 | 0 | 0 |
| **1** | **0** | **0** | **1** | **1** | **1** | **0** | **0** |

1. 2210 - -1410

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  |  | 1 | 1 | 1 | 1 |  |  |
| 0 | 0 | 0 | 1 | 0 | 1 | 1 | 0 |
| 0 | 0 | 0 | 0 | 1 | 1 | 1 | 0 |
| **0** | **0** | **1** | **0** | **0** | **1** | **0** | **0** |

# Task 4 Fixed point binary Answers

Convert these decimal values into a fixed-point binary byte where the first 4 bits represent the whole number part and the the last 4 bits represent the fractional part:

1. 8.510 = 10001000
2. 14.2510 = 1110 0100
3. 0.12510 = 00000010
4. 5.562510 = 01011001
5. 1.937510 = 00011111
6. 0.062510 = 00000001

Convert these fixed-point binary bytes to decimal where the first 3 bits represent the whole number part and the the last 5 bits represent the fractional part:

1. 101010102 = 5.3125
2. 101110112 = 5.84375
3. 001110112 = 1.84375
4. 111110002 = 7.75
5. 000111112 = 0.96875
6. 111111112 = 7.96875